

Quality Insulation Installation Instructions

Many insulation installations have flaws that degrade thermal performance. Four problems are generally responsible for this degradation:

1. There is an inadequate air barrier in the building envelope, or holes and gaps within the air barrier system inhibit the ability to limit air leakage.
2. Insulation is not in contact with the air barrier, creating air spaces that short-circuits the thermal barrier of the insulation when the air barrier is not limiting air leakage properly.
3. The insulation has voids or gaps, resulting in portions of the construction assembly that are not insulated and, therefore, has less thermal resistance than other portions of the assembly.
4. The insulation is compressed, creating a gap near the air barrier and/or reducing the thickness of the insulation.

An energy credit for correctly installing an air barrier and insulation to eliminate or reduce common problems associated with poor installation is provided in the RA3.5.

These instructions cover the most difficult to understand portions of the ENV-21, ENV-22, and ENV-23 compliance documents.

ENV-21-H

Air Infiltration Sealing – Framing Stage for Batt, Loose fill, and SPF

APPROVED MATERIALS

In order to be considered an air barrier, individual materials must have an air permeance not exceeding 0.004 cfm/ft² @ 1.57 lb/ft² (0.02 L/(s•m²) @ 75 Pa) when tested in accordance with ASTM E2178. Products must be installed per manufacturer instructions. Products that meet these requirements are listed below.

All joints/seams for materials that make up the air barrier must be sealed with caulk, foam, tape, or a material specifically designed for building envelope sealing to prevent air infiltration. Products must be installed per manufacturer instructions.

It is the installer's responsibility to ensure the products are installed properly, and it is the HERS rater's responsibility to verify proper installation.

Examples of Approved Air Barrier Materials:

- Plywood – minimum 3/8 inch
- Oriented Strand Board (OSB) – minimum 3/8 inch
- Foil-back polyisocyanurate insulation board – minimum 1/2 inch
- Extruded polystyrene insulation board – minimum 1/2 inch
- Foil backed urethane foam insulation (1 inch)
- Closed cell spray polyurethane foam with a minimum density of 2.0 lb./cu.ft. and a minimum thickness of 2.0 inches
- Open cell spray polyurethane foam with a minimum density of 0.4 to 1.5 lb./cu.ft. and a minimum thickness of 5 1/2 inches
- Exterior or interior gypsum board - minimum 1/2 inch
- Cement board - minimum 1/2 inch
- Built-up roofing membrane
- Modified bituminous roof membrane
- Particleboard - minimum 1/2 inch

- Fully adhered single-ply roof membrane
- Portland cement/sand parge, or gypsum plaster - minimum 5/8 inch
- Cast-in-place and precast concrete
- Fully grouted uninsulated and insulated concrete block masonry
- Structural Sheathing – Meeting ASTM E2178
- House Wrap – Meeting ASTM E2178
- Thermo-ply
- Sheet steel or aluminum
- Dimensional lumber

LINE ITEMS ADDRESSED:

- C 01:** All penetrations through the exterior wall air barrier are sealed to provide an air-tight envelope to unconditioned spaces such as the outdoors, attic, garage, and crawl space.
- C 02:** Exterior wall air barrier is sealed to the top plate and bottom plate in each stud bay.
- C 03:** All electrical boxes including knockouts that penetrate the air barrier to unconditioned space are sealed.
- C 05:** Exterior bottom plates (all stories) are sealed to the floor using the appropriate sealing method.
- C 08:** Fan exhaust ducts that run between conditioned floors to exterior walls including damper at the exterior wall.
- C 09:** Metal tie downs are insulated between exterior framing and tie down.
- C 10:** Hard to access wall stud cavities, such as corner channels or wall intersections, are insulated to the proper R-value prior to the installation of exterior sheathing or exterior stucco lath.
- C 11:** Insulation is installed behind tub, shower, or fireplace enclosures, and exterior stairwells to the R-value listed on the CF1R when located against exterior walls. Insulation is installed before tub, shower, and fireplace are installed.
- C 12:** A solid air barrier is installed, from floor to ceiling, on the inside of exterior walls directly adjacent to tub, shower, or fireplace enclosures. Insulation shall contact all six sides of the air barrier on exterior walls.
- C 13:** All window and door headers shall be insulated to a minimum of R-2. Using continuous rigid insulation sheathing, or SIP headers, or Two-member headers with insulation in between, or Single-member headers with insulation to the exterior.
- D 04:** All dropped ceilings are covered with hard covers and sealed to framing.
- D 05:** All chases are covered with hard covers and sealed to framing.
- D 09:** Double walls that open to the attic are covered with an air barrier and cover has an air tight seal to the framing.
- E 01:** All penetrations in the subfloor above the garage into conditioned space must follow the raised floor air barrier requirements above.
- E 02:** Infiltration between the space above the garage and subfloor is prevented by one of the following methods:
- F 02:** An exterior wall air barrier is required at the intersection of the porch and exterior wall when there is conditioned space on the other side. The exterior wall includes an air barrier where the attic attaches to the conditioned space.
- F 03:** Truss framing blocking is used at the top and bottom of each wall/roof section.
- G 01:** Airtight blocking is installed between joists where the wall rim joist would have been located in the absence of a cantilever.

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LINE ITEM CLARIFICATIONS:

C 01: All penetrations through the exterior wall air barrier are sealed to provide an air-tight envelope to unconditioned spaces such as the outdoors, attic, garage, and crawl space.

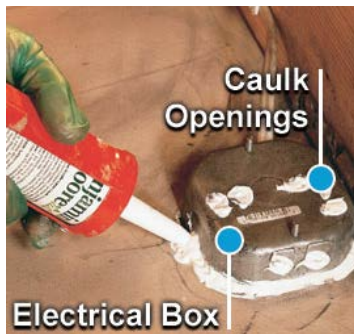
- If stucco or similar air tight products will be applied to the outside of the building, only penetrations in that air barrier need to be sealed. Example: Lineset, electrical boxes.
- If no additional outside air barrier will be installed, then all penetrations, joints/seams where individual materials meet must be sealed with caulk, foam, tape, or a material specifically designed for building envelope sealing to prevent air infiltration. If foam board is the air barrier then it must be taped at all seams. Edges of foam board must be sealed to the surrounding air barrier.
- House wrap can be used as an air barrier when it meets ASTM E2178. All seams, edges and penetrations in the house wrap must be sealed.
- If OSB, plywood, cement board, Thermo-ply, or dimensional lumber are the exterior air barrier, all of the seams and penetrations must be sealed.

C 02: Exterior wall air barrier is sealed to the top plate and bottom plate in each stud bay.

- For multi-story buildings that have a continuous air barrier on the exterior, only the bottom plate of the first floor and the top plate of the top floor need to be sealed to the exterior air barrier.
- It is possible to have a two-story house where the upstairs conditioned space has a smaller footprint than the first story. In such a floor plan, top plates of a first story wall exposed to an unconditioned attic would be sealed to the exterior air barrier.

C 03: All electrical boxes including knockouts that penetrate the air barrier to unconditioned space are sealed.

- Seal electrical boxes to the surrounding air barrier.
- Seal openings (knockouts) in the electrical box.
- Use tape, caulk or foam. Ensure sealing products do not enter into the electrical box.



C 05: Exterior bottom plates (all stories) are sealed to the floor using the appropriate sealing method.

If the exterior air barrier is continuous (from the bottom story to the top story), then the bottom plate of first floor only needs to be sealed.

In order to verify that the bottom plate is sealed, the following are allowed:

- Use a gasket material that is 3.5 inches wide on 2x4, 5.5 inches wide on 2x6; or
- Seal the bottom plate on the inside at junction of concrete and plate with caulk or foam; or
- Watch sealing of the bottom plate to foundation during framing.

C 08: Fan exhaust ducts that run between conditioned floors to exterior walls including damper at the exterior wall.

- Fan exhaust ducts that run between conditioned space, including the space between conditioned floors to exterior walls, shall include a damper at the exterior wall.

C 09: Metal tie downs are insulated between exterior framing and tie down.

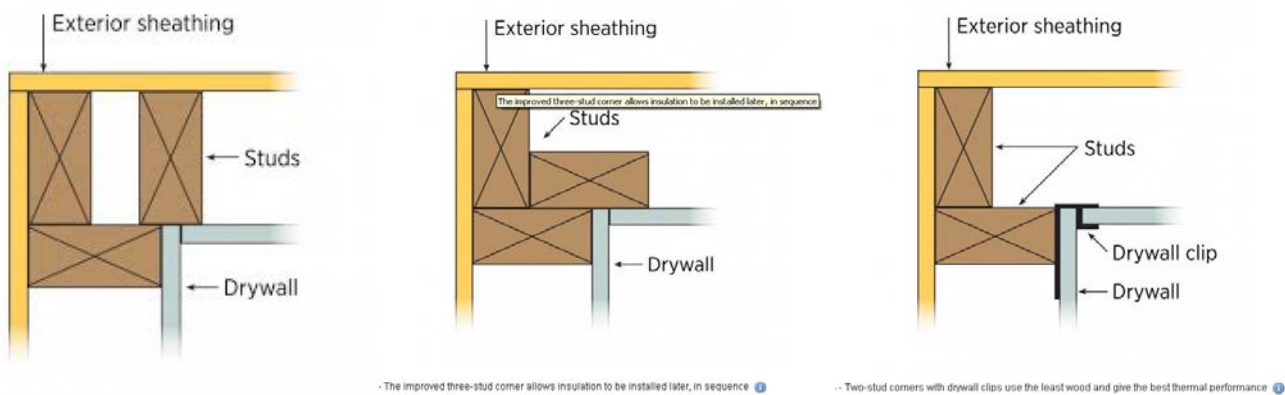
- Metal tie downs shall be fully insulated in a manner that resists thermal bridging through the structural framing assembly.
- If there is room behind the tie down and the exterior framing, ensure it is insulated. It is not required to move the tie down to add insulation.

C 10: Hard to access wall stud cavities, such as corner channels or wall intersections, are insulated to the proper R-value prior to the installation of exterior sheathing or exterior stucco lath.

- Cavities in corner channels or wall intersections that will become inaccessible shall be completely filled with insulation and verified before the exterior sheathing is installed.
- Alternative framing details shown below can be used to eliminate cavities that would become inaccessible after exterior sheathing is installed.

NOTE: When batt insulation is used, it must be cut to fit around framing.

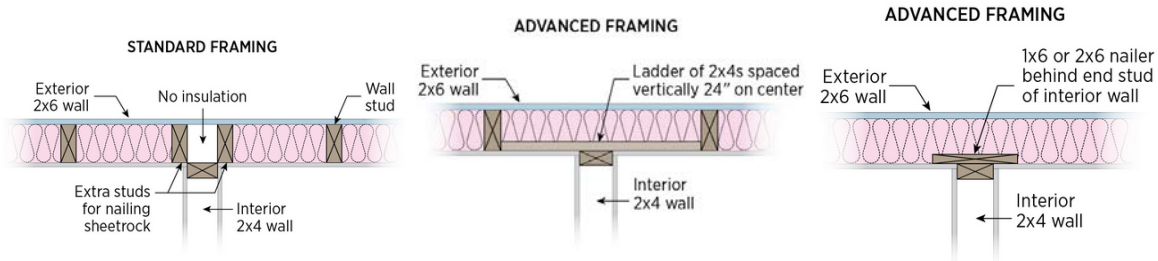
Corner Channels are typically framed in a U-channel. Insulation must be inserted in this space from the outside before the exterior wall sheathing is installed. It is recommended that the advanced framing methods shown below be used.



Typical Corner Framing

Advanced Framing Methods

Wall Intersections where interior walls intersect exterior walls, builders will typically use a conventional T-post detail. Insulation must be inserted in this space from the outside before the exterior wall sheathing is installed. It is recommended that the advanced framing methods shown below are used. In advanced framing, batt insulation must be cut to fit around the 2x4 ladders and the 1x6 or 2x6 nailers.



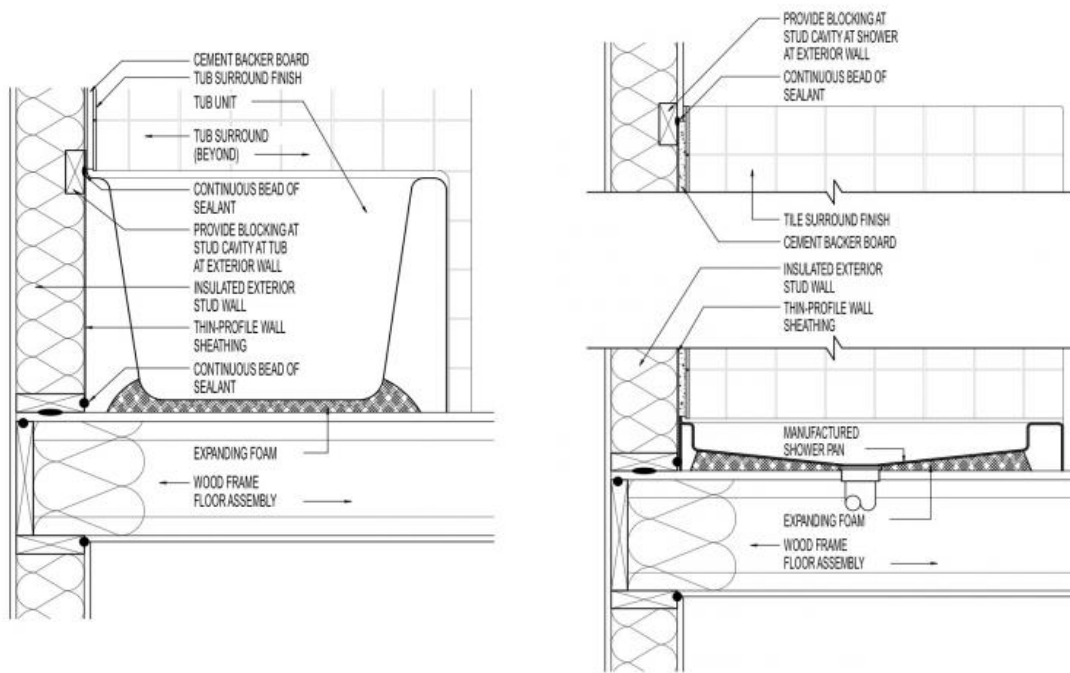
C 11: Insulation is installed behind tub, shower, or fireplace enclosures, and exterior stairwells to the R-value listed on the CF1R when located against exterior walls. Insulation is installed before tub, shower, and fireplace are installed; and

C 12: A solid air barrier is installed, from floor to ceiling, on the inside of exterior walls directly adjacent to tub, shower, or fireplace enclosures. Insulation shall contact all six sides of the air barrier on exterior walls.

- When tubs, showers, fireplace enclosures, or stairwells are installed on exterior walls, builders may forget to insulate and air seal the exterior wall behind those locations. For QII the HERS Rater must visually verify that these locations are properly air sealed and insulated before they become inaccessible.
- The insulation behind the tub or shower must be equivalent to the insulation in adjacent exterior walls and covered with an air barrier that is sealed at all edges and seams to provide a continuous air barrier. Any type of insulation may be installed as long as it completely fills the void and is in full contact on all six sides of the air barrier.

NOTE: The bath tub air barrier is not required to extend to the ceiling at framing stage. Drywall will be installed to the ceiling at a later stage.





C 13: All window and door headers shall be insulated to a minimum of R-2. Using continuous rigid insulation sheathing, or SIP headers, or Two-member headers with insulation in between, or Single-member headers with insulation to the exterior.

The Building Energy Efficiency Standards provide Quality Insulation Installation (QII) compliance credit for R-2 insulated headers. Insulation or wood must fill the cavities, leaving no air gaps in or around the header.

Three options meet the R-2 insulated header requirement:

- A. Two-member header with insulation in between. The header and insulation must fill the wall cavity. Example: a 2x4 wall with two 2x nominal headers, or a 2x6 wall with a 4x nominal header and a 2x nominal header. Insulation is required to fill the wall cavity and must be installed between the headers.
- B. Single-member header, less than the wall width, with insulation on the interior face. The header and insulation must fill the wall cavity. Example: a 2x4 wall with a 3 1/8 inch wide header, or 2x6 wall with a 4x nominal header. Insulation is required to fill the wall cavity and must be installed to the interior face of the wall.
- C. Single-member header, same width as wall. The header must fill the wall cavity. Example: a 2x4 wall with a 4x nominal header or a 2x6 wall with a 6x nominal header. No additional insulation is required because the header fills the cavity.

D 04: All dropped ceilings are covered with hard covers and sealed to framing.

- The 2008 RA allowed the entire drop area to be filled with insulation level with the rest of the attic. This is no longer allowed under the 2013 Standards; hard covers are required.
- Framing of soffits or drop ceilings should be done inside the Air Barrier. This means the drywall has been installed and sealed as required before the soffit or drop ceiling is framed out.

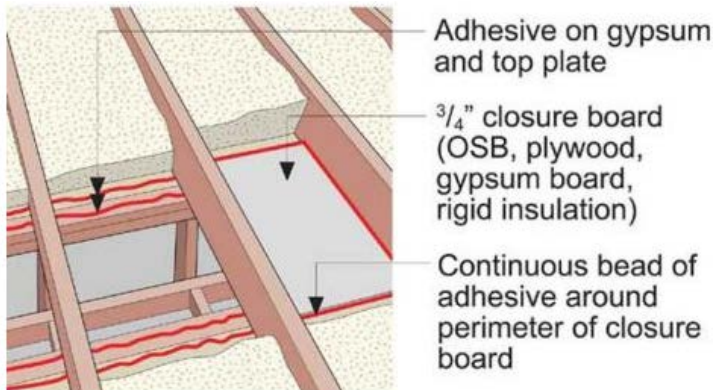


D 05: All chases are covered with hard covers and sealed to framing.

- All vertical chases shall have hard covers sealed to the framing at each plate level.
- See notes for D 04 above.

D 09: Double walls that open to the attic are covered with an air barrier and cover has an air tight seal to the framing.

- Double walls that open to the attic or subfloor must be covered. See notes for D 04 above.
- For double walls on the exterior. An air barrier must be installed covering the double wall if insulation is going to be installed on the exterior wall.



Installing air barrier above a soffit ⓘ



In this picture an air barrier is not required at the double wall because insulation will be installed on the interior wall.

E 02: Infiltration between the space above the garage and subfloor is prevented by one of the following methods:

- All seams where components (including the rim joists, closures, top plates, and subfloor) come together must be sealed with caulk, spray foam, or foam gaskets/tape. Sole plates at the slab of the common wall are to be caulked, foamed, or gasketed to prevent air migration.
- When garage ceiling joists extend across both the living space and the garage, the joist bay cavities above any common walls must be closed off and sealed to prevent air movement within the frame assembly.



Incorrect – Joist bay cavities not sealed



Correct – Joist bays with blocking and sealed

- Insulation can be placed on the ceiling of the garage or in contact with the conditioned subfloor above. Where the insulation will be installed effects the location of the air barrier and sealing.
- Option 2 below is the preferred method.

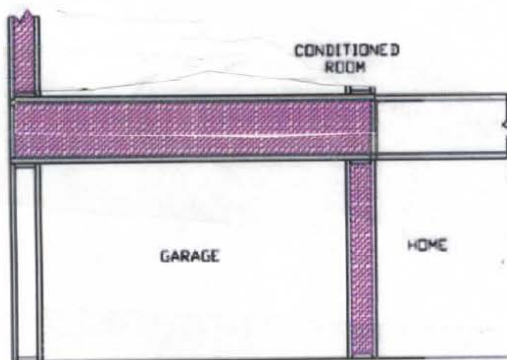
Option 1 – Insulation is placed in contact with the garage ceiling, with a void between the insulation and the conditioned subfloor above. When using this option, the air barrier for the conditioned space above the garage is the garage ceiling and the perimeter blocking.

- Perimeter of insulation must be full depth. Filling space from ceiling to subfloor.
- Seal all edges of the garage ceiling (typically drywall) at the perimeter of the garage to create a continuous air tight surface between the garage and adjacent conditioned space.
- The blocking at the garage and the adjacent conditioned space (house) shall be insulated up to the subfloor.

Option 2 – Insulation is placed in contact with the conditioned subfloor (this is the preferred method). When using this option, the air barrier is the subfloor alone.

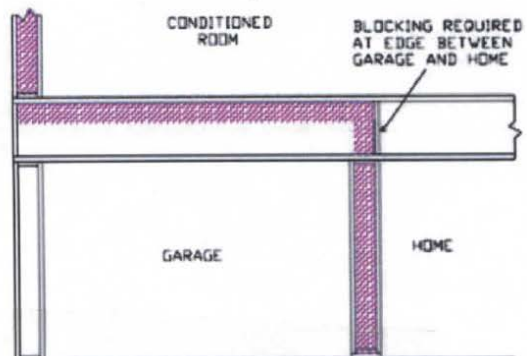
- Seal all subfloor seams and penetrations between the garage and adjacent conditioned space.
- The garage and the adjacent conditioned space (house) shall be insulated up to the subfloor.

2 STORY CONDITIONED SPACE OVER GARAGE
GARAGE & RIM JOISTS INSULATED



Option 1 – Insulation goes from ceiling to subfloor around perimeter.

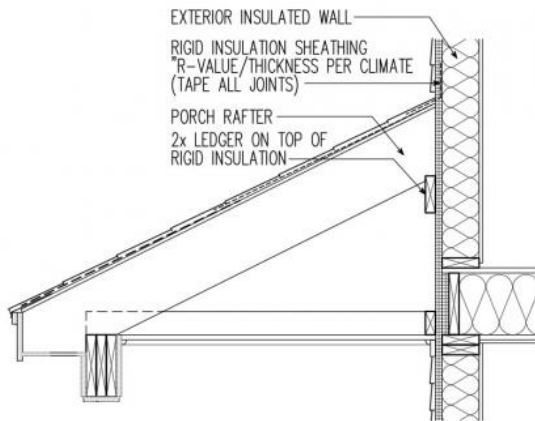
2 STORY CONDITIONED SPACE OVER GARAGE
SUBFLOOR & GARAGE TO HOME TRANSITION
AIR BARRIER & INSULATED



Option 2 – Insulation goes from ceiling to subfloor at blocking to house.

F 02: An exterior wall air barrier is required at the intersection of the porch and exterior wall when there is conditioned space on the other side. The exterior wall includes an air barrier where the attic attaches to the conditioned space.

- Insure all wall insulation is in contact with the air barrier on all six sides. Exterior air barrier is often missed when an attic is attached to an exterior wall.
- Insulation values for these areas must be the same as the rest of the walls. If rigid insulation is installed on the walls it must also be installed in these areas.



G 01: Airtight blocking is installed between joists where the wall rim joist would have been located in the absence of a cantilever.

- Blocking must be installed any time joists goes over an exterior wall or opens into an unconditioned space.



ENV-22-H

Air Infiltration Sealing – Ceiling/Roof Deck

LINE ITEMS ADDRESSED:

- A 04:** Electrical boxes, fire alarm boxes, and fire sprinklers cut into ceilings are sealed to the surrounding drywall. If it is not possible to seal the fixture directly, a secondary air barrier shall be created around the fixture.
- A 06:** Exhaust fan housing is sealed to the surrounding drywall and all holes and seams in the housing are sealed.
- A 09:** Attic access forms an airtight seal between conditioned space and unconditioned space.
- A 10:** When the knee wall is placed on top of a subfloor the open cavity between the subfloor and the ceiling below is sealed.
- A 13:** All top plates of interior and exterior walls are sealed to drywall.
- A 14:** Attic access must be surrounded with a dam at least the same depth as the insulation to prevent loss of ceiling insulation.

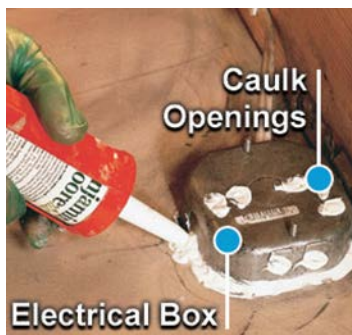
LINE ITEM CLARIFICATIONS:

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- A 04:** Electrical boxes, fire alarm boxes, and fire sprinklers cut into ceilings are sealed to the surrounding drywall. If it is not possible to seal the fixture directly, a secondary air barrier shall be created around the fixture.

Sealing of the above items are required only when they penetrate the ceiling to unconditioned space.

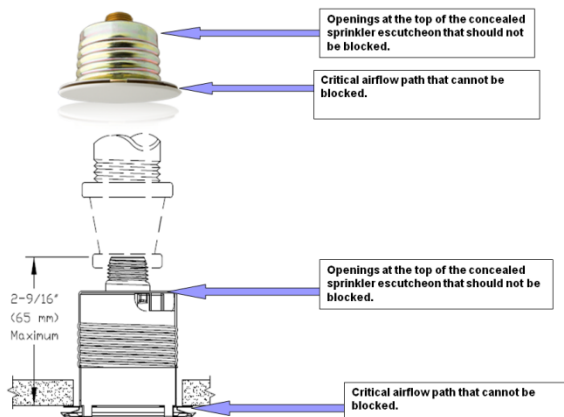
- Seal electrical boxes to the surrounding air barrier.
- Seal openings (knockouts) in the electrical box.
- Use tape, caulk or foam. Ensure sealing products do not enter into the electrical box.



Fire Sprinklers

- Concealed fire sprinklers have openings at the top of the sprinkler that shall not be blocked, sealed or have a secondary air barrier.
- When sprinklers are installed in the ceiling air barrier where the back opens into the attic, it is recommended that flush mount or non-vented recessed sprinklers be used. These do not require air flow through the sprinkler to activate and they can be sealed to the ceiling air barrier.
- See California State Fire Marshal Bulletin 13-007 link:
http://osfm.fire.ca.gov/informationbulletin/pdf/2013/IB-13007_ResFireSpklrsEnergyRegs.pdf.
- Additional link on proper installation:
<http://osfm.fire.ca.gov/codedevelopment/pdf/califfiresprinklercoalition/OSFMCEC10142013.zip>.

Illustration of Critical Airflow Features of a Typical Concealed Fire Sprinkler



Illustrations of typical sprinkler types that generally do not rely on airflow through the ceiling interface for timely sprinkler operation in the event of a fire.

Flush Style



Flush Style



Recessed Style



Flush Style



A 06: Exhaust fan housing is sealed to the surrounding drywall and all holes and seams in the housing are sealed.

- Sealing of the exhaust fan only required when they penetrate the ceiling to unconditioned space. Seal all gaps and holes to unconditioned space with caulk, foil backed HVAC duct tape, or foam. Fibrous insulation is not an air barrier and cannot be used for sealing gaps.

A 09: Attic access forms an airtight seal between conditioned space and unconditioned space.

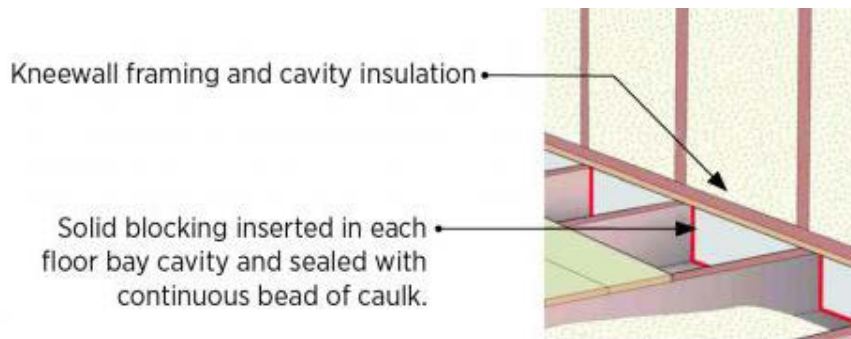
- To air seal the attic access, weather stripping must be added to the frame of the attic access panel. Vertical attic access in a wall requires mechanical compression using screws or latches that will pull the access door tight to the weatherstripping for an airtight seal. A standard door knob, dead-bolt or similar latching mechanism will work to provide mechanical compression for vertical access.



Attic access door has foam or rubber weather stripping.

A 10: When the knee wall is placed on top of a subfloor the open cavity between the subfloor and the ceiling below is sealed.

- Air Barrier must be added to the joist cavity below the knee wall and sealed.



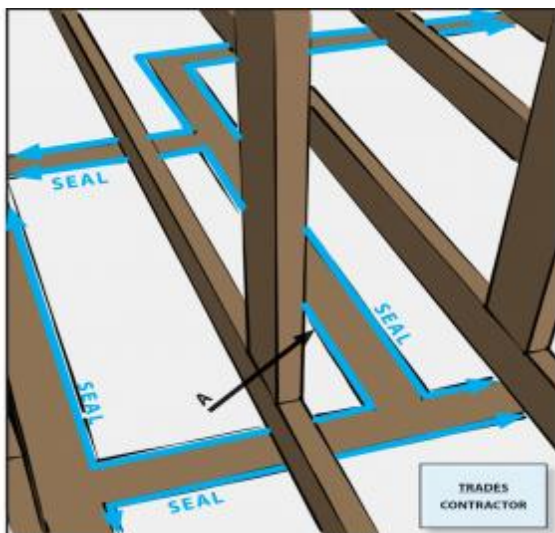
A 13: All top plates of interior and exterior walls are sealed to drywall.

Interior Walls

- Top plates do not need to be sealed unless there is an unconditioned space above.
- Sealing of the top plate can be done from the attic after all the drywall is installed, or from below before drywall is installed.
- If sealing from the attic after drywall is installed, use caulk or foam to seal all top plates to the drywall.
- If sealing from below when the drywall is installed at a later date, a gasket type material must be used. The gasket must be thick enough to fill any irregularities (approximately 1/4 inch thick) between the two surfaces and the gasket must remain flexible so that it can expand/compress and still seal the two materials together when they meet.

Exterior Walls

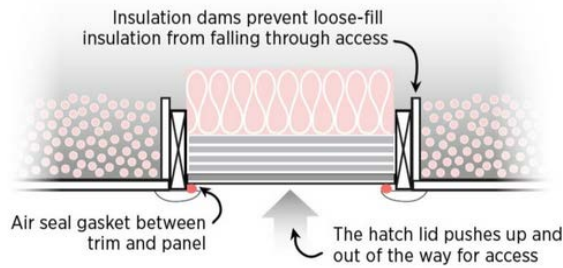
- For multi-story buildings and a continuous air barrier is used (like stucco) only the bottom plate of the first story and the top plate of the top story need to be sealed.
- Use a gasket material that hangs down below the top plate so that it can be verified at a later date; or
- Seal the exterior air barrier to the top plate from the interior so that it can be verified; or
- Rater must watch sealing of the exterior air barrier to the top plate during construction.



Sealing from attic

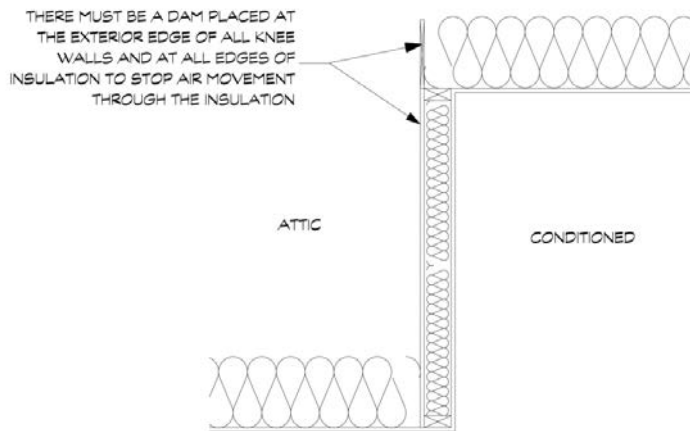
A 14: Attic access must be surrounded with a dam at least the same depth as the insulation to prevent loss of ceiling insulation.

- A dam must be installed around the attic access that is at least the same depth as the required attic insulation to ensure full depth around the attic access.
- Most insulation manufacturer instructions require a rigid dam around the attic access for all types of insulation. Check insulation manufacturer instructions.
- R-38 insulation would require a 13 ¾" to 14 ½" dam. R-48 insulation would require a 17" dam in most situations.
- The depth of the dam would be measured from the ceiling to the top of the dam.



A 15: There must be a dam placed at the exterior edge of all knee walls and at all edges of insulation to stop air movement through the insulation.

- The dam must be at least the same depth as the attic insulation to ensure full depth and to stop air migration into the insulation.
- The dam shall be a solid material to keep the insulation in place. Some of the materials that can be used are listed on the CF2R-ENV-21-H.



ENV-23-H

Insulation Installation

LINE ITEMS ADDRESSED:

- B 08:** An air barrier is installed at all exposed edge faces of batt, loose fill and SFP insulation.
- C 10:** Knee walls – an air dam the full depth of the ceiling insulation is added to the exterior edge of the knee wall so the ceiling insulation overlaps the knee wall to the full depth of the ceiling insulation.
- C 13:** Attic access must have a dam around the access to at least the same depth as the insulation.
- C 17:** Steel-framed knee walls, skylight shafts, and gable ends - external surfaces of steel studs are covered with insulation.
- D 04:** Double walls and bump-outs - insulation fills the cavity, or additional air barrier is installed so the insulation fills the cavity and is in contact with the insulation on all six sides unless SPF is used. Insulation shall be installed on the exterior of the double walls/bump-outs.
- D 06:** Electrical panel in exterior insulated wall - the panel is air tight and insulation is installed behind the panel.

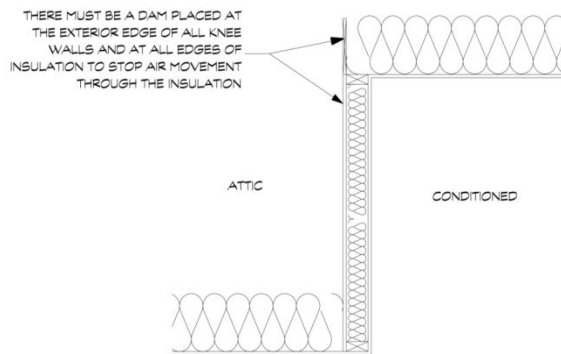
LINE ITEM CLARIFICATIONS:

B 08: An air barrier is installed at all exposed edge faces of batt, loose fill and SFP insulation.

- This is to stop air movement into the insulation and to ensure full depth of insulation.
- Typical locations where this occurs is on top of knee walls, around fireplace and flues.
- SPF does not require an air barrier if it can be installed to its full depth.

C 10: Knee walls – an air dam the full depth of the ceiling insulation is added to the exterior edge of the knee wall so the ceiling insulation overlaps the knee wall to the full depth of the ceiling insulation.

- The dam must be at least the same depth as the attic insulation to ensure full depth and to stop air migration into the insulation.
- This shall be a solid material to keep the insulation in place. Some of the materials that can be used are listed on the CF2R-ENV-21-H.

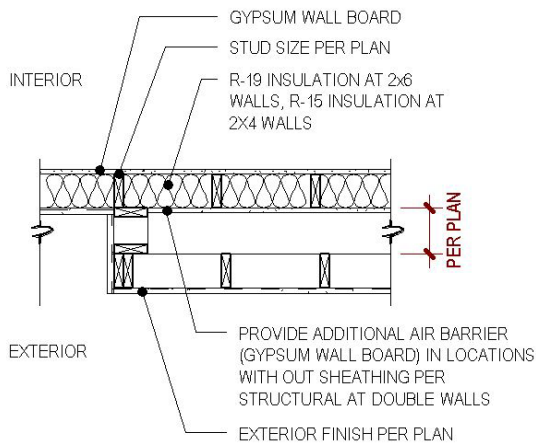


C 13: Attic access must have a dam around the access to at least the same depth as the insulation.

- A dam must be installed around the attic access that is at least the same depth as the attic insulation to ensure full depth around the attic access.
- Most insulation manufacturer instructions require a rigid dam around the attic access for all types of insulation. Check insulation manufacturer instructions.
- For R38 most insulation would require a 13 ¾ to 14 ½" dam. R48 would require a 17" dam in most situations.
- The depth of the dam would be measured from the ceiling to the top of the dam.

D 04: Double walls and bump-outs - insulation fills the cavity, or additional air barrier is installed so the insulation fills the cavity and is in contact with the insulation on all six sides unless SPF is used. Insulation shall be installed on the exterior of the double walls/bump-outs.

- All wall insulation must be in contact with the air barrier on all six sides, unless SPF is used.
- Allowed materials that can be used as the interior air barrier are listed in the CF2R-ENV-21 and must be installed per manufacturer instructions. Verify if house wrap manufacturer instructions allow material to be installed in these locations.
- To keep the integrity of the building envelope it is best to keep the air barrier and insulation in one continuous plane. In situations where there is a double wall or bump out it is best to keep the insulation on the interior wall. An air barrier must be added to the exterior of the insulation so it is in contact with air barrier on all six sides. The form will be changed in the future to not require insulation on the exterior.



INSULATION AT INTERIER DOUBLE WALL





In this example 2 inch spacers are added to the exterior air barrier. Insulation is only required on the interior side of the air barrier not between the spacers.



In this example it would be best to insulate the interior wall. An air must be added to the interior wall that is sealed to the bottom plate, top plate, and all penetrations sealed. Ensure interior bottom plate is sealed to subfloor. A rigid air dam must be added above the interior wall similar to Line Item C10 in this document.

D 06: Electrical panel in exterior insulated wall the panel is air tight and insulation is installed behind the panel.

- When an electric panel is installed on insulated wall the panel must be sealed.
- Seal parameter of electrical panel to the exterior air barrier.
- Seal all openings in the panel.
- Use tape, caulk or foam. Ensure sealing products do not enter into the electrical pane.